Vol. IV.
No. LXXXV.

AUGUST 15, 1876.

Price
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THE TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

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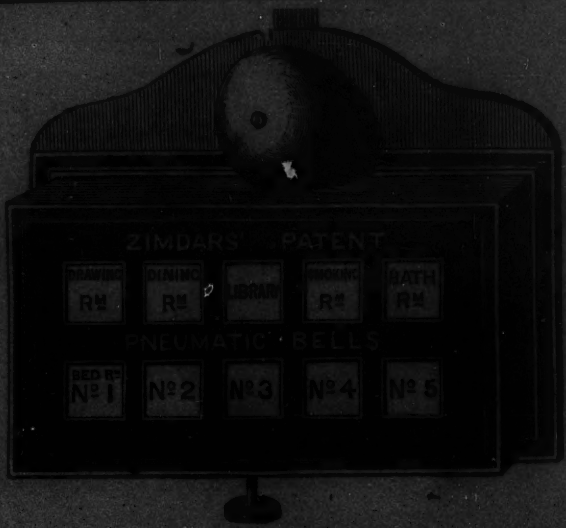

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VOL. IV. AUGUST 15, 1876. No. LXXXV.

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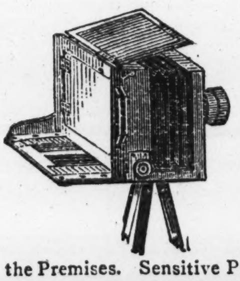

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THE TELEGRAPHIC JOURNAL.

Vol. IV.—No. 85.

THE NATURE OF THE ZODIACAL LIGHT.

The zodiacal light, as is known, is a faint nebulous aurora accompanying the sun, and visible immediately before sunrise or after sunset: it was first observed by Kepler. It has a flat lenticular form, and is placed obliquely in the horizon, the apex extending to a great distance in the heavens. Its direction is in general nearly in the plane of the sun's equator; hence it is scarcely visible in our latitudes, except at particular seasons, when that plane is nearly perpendicular to the horizon. Among various explanations that have been given of the phenomenon, Cassini thought it might be caused by the confused light of a multitude of small planets circulating round the sun. Another hypothesis, which Laplace disposed of, was that which ascribed it to the atmosphere of the sun. It has generally been supposed, in the present day, that it forms the outer part of the solar corona.

In a recent number of the Proceedings of the Reale Istituto Lombardo, the numerous observations of the zodiacal light by Jones have been subjected to careful examination by M. Serpieri, and he arrives at the conclusion that the light is an electrical aurora preceding and following the sun round the earth.

As the northern light is a local phenomenon, connected with the hour of local time, so also is the zodiacal light, which coincides with the hours which follow the setting, and precede the rising, of the sun.

The so constant phenomenon of the phases of rising (in the evening) and of sinking (in the morning) of the apices of the zodiacal cone, evident from Jones's drawings, demand absolutely (says M. Serpieri) the explanation referred to. When the cone is grown to a maximum in one place, it is at other places in the beginning of its rise. There are, therefore, just as many zodiacal cones as there are horizons. Similarly, Donati found there were just as many polar lights on Feb. 4th, 1874, as there are degrees of longitude from the furthest parts of Asia, through Greenwich, on to America.

As a local meteorological phenomenon, the zodiacal light has different forms, inclinations, and sizes, in different lands. The differences the author has met with in this respect he is unable to explain by parallax. On one and the same day, Heis in Münster has observed the axis inclined to the North, and therefore the apex appearing simply north of the ecliptic; while Jones in Rio Janeiro saw the axis inclined southwards, and the apex south of the ecliptic.

The hypothesis of a solar reflection he also excludes on account of the spectroscopic characters of the zodiacal light, which also appear to him to favour his explanation.

The annual curve of elongations of the apices shows their maxima to be in and after the solstices, and the minima in and after the equinoxes; that is, the maxima at epochs in which the earth goes through the nodes of the sun's equator, and the minima when we are at the greatest distances from the sun's equator. Perhaps, the author suggests, the electric currents of the sun which go to the earth, and produce the zodiacal and polar lights, when they are in the positions given in reference to the horizon, are greater in the first epoch, less in the other. He further offers proof, that these maxima and minima of the elongations of the apices do not depend on the portions of the zenith relating to the ecliptic.

The phenomenon of pulsations, certainly observed by Jones, seem to indicate still further a dynamical state of the great zodiacal cone, which is fed by continual radiations—radiations which appear intermittently, if the resistances increase, and produce the pulsations; with which is associated not a greater, but a smaller development of the cone than usual.

This new conception of the zodiacal light opens a whole field for further investigations and theoretical speculations. M. Serpieri's communication is merely of a preliminary character, and he hopes shortly to publish further results of his inquiry.

ON IRRECIPROCAL CONDUCTION OF ELECTRIC CURRENTS.*

In the passage of electrical currents through electrolytes, M. du Bois Reymond happened to observe that the strength of current is different in the two opposite directions, when the electrodes are of different size. This phenomenon, which has been denoted by the name of "irreciprocal conduction," has been made by M. Christiani the subject of a special investigation. He finds it to be most pronounced, where a fine metallic point and a plate standing opposite it are employed as electrodes, and he names the direction from the plate to the point the "platydrom," the opposite direction the "oxydrom."

---

* Ueber irreciproke Leitung electrischer Ströme. Von A. Christiani. Berlin, 1876. Friedländer.

For a study of the phenomenon, a concentrated solution of Cl Na is specially suitable, along with electrodes of platina. It is further best to employ the single-induction currents of a sliding inductorium; they are sent simultaneously through the liquid and through a galvanometer. Being of momentary duration they produce no marked decomposition. In this way, then, the rule is demonstrated, that weak currents are stronger in oxydromal direction, while stronger currents are stronger in platydromal direction, than conversely. Thus currents of less density go more easily from the point to the plate, currents of greater density more easily from the plate to the point.

In every combination there is a determinate mean strength of current, with which in both directions the current appears of the same strength. This point, which is named the "reciprocal point," has a very constant position when, in the same combination, *ceteris paribus*, only the distance between the electrodes is altered. It is found, viz., that the reciprocal point always occurs with one and the same distance of the secondary coil. If, on the other hand, resistances be introduced into the metallic circuit of the induction current, we must seek a shorter distance of the secondary coil, in order to obtain the reciprocal point, and it appears that this point always corresponds to one and the same tension of the electrodes. In a given mixed circuit, therefore, with electrodes of unequal size, the conduction occurs reciprocally only with a quite determinate electro-motive force. It follows, that the irreciprocal conduction is a function of the tension of the electrodes.

The position of the reciprocal point is further, *cet. par.*, dependent on the size of point (of the one electrode); with diminution of the latter, the former sinks to smaller current values. These phenomena occur in the same manner in a large number of electrolytes, with use of different metallic electrodes. Since, moreover, they occur with quite unpolarisable combinations, *e.g.*, with zinc electrodes in zinc-vitriol solution, irreciprocal conduction cannot depend on polarisation. The examination of different electrolytes brings to light an important relation between the position of the reciprocal point and the molecular weight of the decomposed substances. If, viz., that position be denoted by a number, the "dysodic constant," which is obtained by dividing the strength of the current sent through a metallic circuit by the reciprocal current in the electrolyte, it appears that this is nearly proportional to the molecular weight. With some combinations, however, multiples of the molecular weights must be taken, in order to establish the law.

M. Christiani develops, in closing, a theory of of electrolysis, in which he seeks to explain irreciprocal conduction and the discovered molecular law. According to this theory, we are to conceive that the electricity in the solutions is transported from one electrode to the other, not at all by the water, but only by the ions, and that only in one direction, from the anode to the cathode. For further exposition of the theory, we must refer to the original.—*(Der Naturforscher.)*

TELEGRAPH CONSTRUCTION.

BY JOHN GAVEY.

(Continued from page 184.)

It will be seen from foregoing considerations that the strength of a rectangular cantilever or girder increases inversely as the length, because each addition to the length increases the leverage of the weight; and directly, as the width, and as the square of the depth. As the width, because every increase of width increases the number of fibres to resist the strain; and as the square of the depth, because every addition to the latter increases both the short arm of the lever, and the number of fibres resisting fracture. The actual strength of beams is calculated by means of the following formula, which applies to the strength of beams supported at both ends and loaded in the centre. The strength of a cantilever is readily obtained by the proportion already given —viz., one-half the value for a uniformly-loaded, and one-fourth for one loaded at the extremity.

Let W = weight in pounds applied at the centre of a beam, supported at both ends; C a constant derived from experiment, *b* the breadth, *d* the depth, and *l* the length between the supports.

$$\text{Then W.} = \text{C.}\,\frac{b\,d^2}{l}$$

The constant C represents the breaking strain of beams, one foot long and one inch square, supported at their extremities. In page 195, vol. iii., we gave a list of these, taking the mean of results obtained by such eminent authorities as Barlow, Tredgold, and others. In most of these experiments, however, beams not exceeding two inches square were employed; but it appears that results on a large scale, with massive balks, give a lower constant than those quoted already. This may readily be understood as arising from the fact, that in experiments with small lengths, only the soundest timber would be selected, whereas in a whole balk, the timber would not be perfectly homogeneous throughout; knots, cross-grain, imperceptible shakes, and sap-wood, materially reducing the strength. Hence, constants deduced from experiments (which unfortunately are not published for all classes of timber) on whole balks, give far more satisfactory and reliable results than those previously quoted, notwithstanding the high authority by which they were issued.

The following table, which is extracted from a paper read at the Institution of Civil Engineers, by Mr. C. Graham Smith, contains constants, obtained by experiments on whole balks of timber made for the engineer of the Mersey Dock Board.

Timber.	*Scantling of Balks under Experiment.*	*Span or Length between Supports.*	*No. of Beams tested.*	*Average Breaking Load at centre.*	*Constant for these Beams.*	*Constant deduced from a comparison with other experiments by Author of Paper.*
				TONS.	LBS.	
Baltic memel fir	13½″ × 13½″	10′.6″	2	30. 5	291.	
Quebec yellow pine ...	14″ × 15″	10.6	2	30. 5	227.	246
Quebec yellow pine ...	14 × 15	10.6	2	36.	268.	
Baltic fir—average ...	6 × 12	12.3	2	9. 5	302.	Best, 291 Seconds, 227
Pitch pine	6 × 12	12.3	2	10.35	328.	380.
Pitch pine	14 × 15	10.6	2	60.	448.	
American red pine ...	6 × 12	12.3	2	8.	254.	257

Experiments made by Mr. Edwin Clark, during the construction of the Britannia Tubular Bridge, on beams of American red pine, twelve inches square, give corresponding results, the average constant being 270; that for a beam cut from the bottom of a balk being 288, from the top 257, and from the centre 256.

The following table is prepared on the assumption that 270 may be taken as an average constant for red pine, and it will give an approximate idea of the strength of rectangular beams, one foot long, supported at both ends and loaded in the middle, and likewise of cantilevers loaded at one end. It simply becomes necessary to divide the figures opposite the respective depths by the length in feet of any given beam, within the limits of the table, to find its strength. The safe load is taken at one-fourth of the breaking strain, the figure four being in this case termed the factor of safety.

TABLE SHOWING SAFE LOADS AND BREAKING STRAINS IN LBS. OF VARIOUS RECTANGULAR BEAMS OF RED PINE.

Depth of Beam.	SQUARE BALK.				BALK 12″ WIDE.			
	Supported both ends and loaded in middle.		*Cantilever loaded at one end.*		*Supported both ends and loaded in middle.*		*Cantilever loaded at one end.*	
	Safe Load. 1	*Breaking Strain.* 2	*Safe Load.* 3	*Breaking Strain.* 4	*Safe Load.* 5	*Breaking Strain.* 6	*Safe Load.* 7	*Breaking Strain.* 8
4″	8640	34560	2160	8640	25920	103680	6480	25920
4½	12301	49206	3075	12301	32805	131220	8201	32805
5	16875	67500	4218	16875	40500	162000	10125	40500
5½	22461	89844	5615	22461	49005	196020	12251	49005
6	29160	116640	7290	29160	58320	233280	14580	58320
6½	37074	148296	9268	37074	68445	273780	17111	68445
7	46305	185220	11576	46305	79380	317520	19845	79380
7½	56953	227814	14238	56953	91125	364500	22781	91125
8	69120	276480	17280	69120	103680	414720	25920	103680
8½	82906	331626	20726	82906	117045	468180	29261	117045
9	98415	393660	24603	98415	131220	524880	32805	131220
10	135000	540000	33750	135000	162000	648000	40500	162000
11	179685	718740	44921	179685	196020	784080	49005	196020
12	233280	933120	58320	233280	233280	933120	58320	233280
13	296595	1186380	74148	296595	273780	1095120	68445	273780
14	370440	1481760	92610	370440	317520	1270080	79380	317520
15	455625	1822500	113906	455625	364500	1458000	91125	364500
16	552960	2211840	138240	552960	414720	1658880	103680	414720
17	663255	2653020	165813	663255	468180	1872720	117045	468180
18	787320	3149280	196830	787320	524880	2099520	131220	524880
19	925965	3703860	231491	925965	584820	2339280	146205	584820
20	1080000	4320000	270000	1080000	648000	2592000	162000	648000

In designing beams to withstand any given strain, it is obvious that as the strength increases as the square of the depth, it is advantageous to add material to the depth rather than to the breadth; but it must, however, be borne in mind that in endeavouring to increase the strength of a beam, by distributing the material in the depth, at the expense of the breadth, if this process is carried too far, the beam will fail by twisting. The strongest rectangular beam that can be cut out of a round log of timber should have depths proportioned to its width as 7 to 5 nearly.

For square beams the formula $W = C \frac{b d^2}{l}$ becomes converted in $W = C \frac{d^3}{l}$ as in such cases $b d^2 = d^3$. From this it follows that the formula for a cylindrical beam becomes $W = C \frac{d^3}{l}$ where d is the diameter of the beam. The constant, however, in this case, would differ from that used for square timber.

The strength of a square beam is to that of a cylindrical one of equal sectional area, as 1000 is to 845. The area of a square beam is to that of a round one, whose diameter equals one side of the square, as 10,000 is to 7,853. Combining those ratios, the strength of a round beam is readily deduced from that of a square one whose side equals the diameter, as given in the previous table, by reducing the strength of the former in the proportion 1000 to 663, or, in other words, by multiplying the former tabulated results by 663, and striking off the last three figures. The subjoined table gives these results for red pine, for diameters from 4″ to 20″. It likewise gives similar information for larch timber. The constant for larch is given by Barlow as 280. Through the considerations already mentioned, and because it is usual in telegraph construction to employ timber largely composed of sap, this constant is reducing to 200, in preparing the table—

TABLE OF STRENGTH OF CYLINDRICAL CANTILEVERS IN LBS.

Diameter.	LARCH.		RED PINE.	
	Safe Load. 1	*Breaking Strain.* 2	*Safe Load.* 3	*Breaking Strain.* 4
4″	1058	4233	1432	5728
4½	1506	6027	2038	8155
5	2067	8268	2797	11188
5½	2751	11005	3722	14891
6	3572	14288	4833	19333
6½	4541	18166	6145	24580
7	5672	22689	7675	30700
7½	6976	27906	9439	37759
8	8467	33868	11456	45826
8½	10155	40623	13741	54966
9	12055	48223	16312	65249
10	16537	66150	22376	89505
11	22011	88045	29782	119131
12	28576	114307	38666	154664
13	36357	145431	49160	196642
14	45378	181515	61400	245601
15	55814	223256	75519	302079
16	67737	270950	91653	366612
17	81248	324994	109934	439738
18	96446	385786	130498	521993
19	113430	453722	153478	613914
20	132300	529200	179010	716040

The strength of a hollow cylindrical beam is to that of a solid one containing the same weight of material as

$$\frac{D^4 - d^4}{D} : - \delta^3$$

where D is the exterior and d the interior diameter of the hollow beam, and δ the diameter of the solid one.

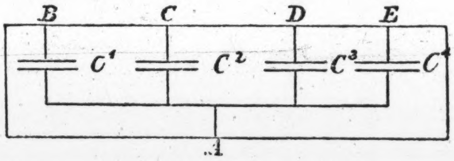
ON THE PROOF OF A FORMULA GIVEN BY MR. KEMPE

In the *Telegraphic Journal* of April 1st, 1876.

BY C. HOCKIN, M.A.

No. 1.

THE formula given by* Mr. Kempe in your number of 1st April last is so useful an addition to the methods in ordinary use for discovering the position at which a cable has been broken when imperfect connection with earth is made, that your readers may not perhaps consider another proof, and some further developments, altogether uninteresting.



Let any number of condensers $C_1, C_2 \cdot\cdot C_4$ discharge through a linear conductor, the discharges taking place at different points of the conductor.

Assume that originally the condensers are charged to any arbitrary potentials and hold quantities of electricity $Q_1, Q_2 \cdot\cdot Q_4$ respectively. Then if $r_1, r_2 \cdot\cdot r_5$ are the resistances of the circuits AB, BC · · EA respectively, and $a_1, a_2 \cdot\cdot a_5$, the currents flowing at the time t through the same circuits in the direction A B E A, we have by Kirchoff's law—

$$r_1 a_1 + r_2 a_2 + \cdot\cdot + r_5 a_5 = 0$$

Always and therefore since each term is always finite—

$$\int_0^\infty (r_1 a_1 + \cdot\cdot + r_5 a_5)\, dt = 0$$

Or if $q_1, q_2 \cdot\cdot q_5$ are the total quantities of electricity that flow through the same branches—

$$r_1 q_1 + \text{——} + r_5 q_5 = 0$$

But since the condensers ultimately discharge themselves completely—

$$Q_1 = q_2 - q_1$$
$$Q_2 = q_3 - q_2$$
$$\cdots\cdots\cdots\cdots\cdots\cdots$$
$$Q_4 = q_5 - q_4$$

$$\therefore r_1 q_1 + r_2(Q_1 + q_1) + \&c + r_5(Q_1 + Q_2 + Q_3 + Q_4 + q_1) = 0$$

and

$$-q_1(r_1 + r_2 + \cdot\cdot + r_5) = \left.\begin{array}{r} Q_1(r_2 + r_3 + r_4 + r_5) \\ + Q_2(r_3 + r_4 + r_5) \\ + Q_3(r_4 + r_5) \\ + Q_4 \; r_5 \end{array}\right\} \cdot\cdot\cdot \text{ I}$$

---

* A similar investigation has been given also by Dr. Werner Siemens in a paper printed by the Society of Telegraphic Engineers.

Or, in words, the total discharge through the branch B A is the algebraic sum of the several discharges that would take place through it did each condenser exist separately, in which case the proportion of the charge of each condenser flowing in either direction from its point of junction with the conductor would clearly be proportional to the conducting power of the circuit in the same direction. But the current at any moment is not the sum of the several currents that would exist from the discharge of the condensers separately. It is to be remarked that the proof holds whether the condensers have internal resistance or not; all that is assumed being that at starting they hold certain definite quantities of electricity and ultimately are completely discharged.

Now a cable may be regarded as a linear conductor, through which a very great number of very small condensers are discharged, the total capacity discharging into any length of the cable being proportional to that length, and the resistance of the conductor being also everywhere proportional to its length.

Then if c = capacity of the cable per unit length,
v = original potential at distance x from one end of the cable.
l = total length of cable.

The discharge through the end at which x is is supposed = 0 is by equation I—

$$= \int_0^l c\, v \frac{l-x}{l}.\, dx \text{ - - - - - - - II}$$

which is Mr. Kempe's equation.

The following proof is perhaps more direct:—

Let v = potential at distance x from one end of cable at time t.
V = potential at same point at time $t=o$.
k resistance per unit length of conductor.
γ current in the direction in which x is measured, at the point x and at the time t.
γ_0 and γ_2 the currents at points where $x = o$, and $x = l$ respectively.

Then the well-known equations of motion are—

$$\frac{d^2v}{dx^2} = kc \frac{dv}{dt} \text{ - - - - - III}$$

$$-k\gamma = \frac{dv}{dx} \text{ - - - - - IV}$$

Substituting in III from IV—

$$\frac{d\gamma}{dx} = -c\frac{dv}{dt}$$

Integrating with regard to x, we have, since x and t are independent variables,

$$\gamma - \gamma_0 = -c\frac{d}{dt}\int_0^x v\, dx \text{ - - - - - V}$$

or

$$-\frac{1}{k}\frac{dv}{dx} - \gamma_0 = -c\frac{d}{dt}\int_0^x v\, dx$$

Integrating a second time since γ_0 is not a function of x,

$$-\frac{1}{k}\left(\underset{x=l}{v} - \underset{x=o}{v}\right) - \gamma_0 l = -c\frac{d}{dt}\int_0^l dx \int_0^x v\, dx$$

$$= -c\frac{d}{dt}\int_0^l (l-x)\, v.dx$$

But if r is the resistance from the end at which $x = l$ to earth and g the resistance at end where $x = 0$—

$$-\frac{1}{k}\left(r\gamma_2 + g\gamma_0\right) - \gamma_0 l = -c\frac{d}{dt}\int_0^l (l-x)\, v.dx$$

Integrating with regard to t, since v = V when $t = o$, and $v = o$ when $t = \infty$

$$-r\int_0^\infty \gamma_2\, dt - (g + kl)\int_0^\infty \gamma_0\, dt = c\,k\int_0^l (l-x)\, \mathrm{V}\, dx$$

Again, from (V)

$$\gamma_2 - \gamma_0 = -c\frac{d}{dt}\int_0^l v\, dx$$

$$\therefore \int_0^\infty \gamma_2\, dt - \int_0^\infty \gamma_0\, dt = c\int_0^l \mathrm{V}\, dx$$

and if Q_1 is the whole discharge at end $x = l$
and Q_0 is the whole discharge at end $x = o$

$$Q_1 = \int_0^\infty \gamma_2\, dt,\quad Q_0 = -\int_0^\infty \gamma_0\, dt$$

$$\therefore (g + kl)\, Q_0 - r\, Q_1 = c\,k\int_0^l (l-x)\, \mathrm{V}\, dx$$

$$\text{and } Q_0 + Q_1 = c\int_0^l \mathrm{V}\, dx$$

$$\therefore Q_0 = \frac{c}{r+g+kl}\int_0^l (r + kl - kx)\, \mathrm{V}\, dx.$$

But if the cable is originally charged by a battery of internal resistance b and electro-motive force E—

$$\mathrm{V} = \mathrm{E}\frac{r + kl - xk}{r + kl + b}$$

and

$$Q_0 = \frac{c}{r+g+kl}\int_0^l \frac{(r + kl - kx)^2\, dx}{r + b + kl}$$

$$= \frac{c\,\mathrm{E}}{3\,k}\,\frac{(r+kl)^3 - r^3}{(r+g+kl)\,(r+b+kl)}$$

Suppose that by observation $r + k\,l$ is found equal to f and that Q_0 is the quantity held by a length of cable of resistance ρ under electro-motive force E and that z is the resistance of the cable up to the fault—

$$\text{then } \frac{\rho}{k}.\, c.\, \mathrm{E} = Q_0$$

$$\text{and } \rho = \tfrac{1}{3}\,\frac{f^3 - (f-z)^3}{(f+b)\,(f+g)}$$

$$\text{or } z = f - \sqrt[3]{f^3 - 3\,\rho\,(f+b)\,(f+g)} \text{ - - - VI}$$

the same expression as given by Mr. Kempe.

In applying this test in practice, it will be found that the cable is never quite free from earth currents, and commonly a very large correction will have to be made for this disturbing cause.

It is probable that if 100 volts are employed to make the test, the electro-motive force at the fault, polarisation being taken into account, will not often fall short of one volt.

Suppose this proportion to hold, and that the discharge takes place through a galvanometer taking one second to make a quarter complete vibration—

The discharge can never exceed $E.\, c.\, \frac{z}{k}$.

The quantity sent through the cable by the electro-motive force at the broken end is $\frac{1}{100}\,\frac{E}{f}$ per second, nearly—

The correction is therefore not less than

$$\frac{k}{100.\, f.\, c.\, z.}$$

Or if c is taken as 0·3 micofarads per knot,

f is expressed in ohms and l is the length of cable in knots of which the resistance is z.

Then the ratio becomes

$$\frac{10^6}{100.\, f.\, c.\, l.} = \frac{10^5}{3.\, f.\, l.}$$

And the quantity of electricity due to the permanent current produced by the electro-motive force at the fault passing in one second will be equal in amount to the whole true discharge, very nearly in the three following circumstances:—If f does not exceed 33,000 ohms, one knot of cable being a circuit; or if f does not exceed 3,300 ohms, ten knots of cable being in circuit; or if f does not exceed 990 ohms, one hundred knots of cable being in circuit. For longer lengths of cable, unless the resistance of the core is less than 10 units per knot, the correction will not equal the whole true discharge, unless the electro-motive force at the fault exceed the value assumed above—namely, one per cent. of the electro-motive force of the testing battery.

To find the exact form of the correction, assume ϵ to be the electro-motive force at the fault, and suppose ϵ to be reckoned positive when it acts in the same direction as E.

Then the whole quantity of electricity flowing through the galvanometer during the discharge is due first to the original charge from the battery E; secondly, to an alteration in the charge due to the electro-motive force ϵ, caused by the change in the total resistance of the circuit when the galvanometer is substituted for the battery E; and thirdly, to the constant electro-motive force ϵ acting through the resistance $f + g$.

If for a moment we put $E = n\,\epsilon$ it is not difficult to see that with the former notation

$$Q_0 = \frac{E}{n}.\, t\, \frac{1}{g+f} + \tfrac{1}{3}\,\frac{c}{k}\,\frac{f^3 - (f-z)^3}{(f+b)\,(f+g)}\left(E - E\,\frac{1}{n}\,\frac{b-g}{f+g}\right)$$

and if q_0 is the true discharge and is by experiment found as before to be equal to $E.\, c.\, \frac{\rho}{k}$.

then

$$z = f - \sqrt[3]{f^3 - 3\,\frac{\rho\,(f+b)\,(f+g)}{1 - \frac{1}{n}\,\frac{b-g}{f+g}}} \text{ - - - - - - - VII}$$

Where n is to be reckoned *positive* if the current due to the fault is in a *direction opposite* to that of the discharge and *vice versâ*.

The galvanometer needle is urged partly by the constant current due to the E.M. F at the fault, partly by the varying current due to the discharge. To obtain the throw that would have resulted from the discharge only from the whole throw observed, a galvanometer should be used with heavy needles, the motion of which is not greatly affected by the resistance of the air; the total angular motion should be small, and magnified for observation by a mirror as usual.

Then, if the needle starts from its position of rest when no current exists in the galvanic coil, and the deflection due to the discharge that is observed is d; and if d_1, is the permanent deflection found after the throw and due to the permanent earth current, which should be observed as soon as possible after the discharge; then, D, the deflection due to the *true discharge only*, is given by

$$\left.\begin{array}{l} D = \sqrt{d^2 - 2\,dd_1} \\ \text{if } d \text{ and } d_1 \text{ are in the same direction} \\ \text{or } D = \sqrt{d^2 + 2\,dd_1} \end{array}\right\} \text{ - - - - VIII}$$

if d and d_1 are in opposite directions, very nearly.

(To be continued.)

VOLTAIC ELECTRICITY.

BY PROFESSOR TYNDALL, D.C.L., LL.D., F.R.S.

Lecture V.

When we examine the distribution of heat in the circuit, we find ourselves in the presence of that great principle of constancy as regards the energies of Nature which is the crowning achievement of our times. If we burn a piece of wood upon a hearth the heat is then and there liberated; and if we burn zinc in dilute sulphuric acid, the heat is then and there liberated. But the commingling of that mysterious thing which we call an electric current with the phenomena changes their aspect. If the zinc and the dilute sulphuric acid form part of a voltaic battery, then the heat produced by the combustion of the zinc may be or may not be liberated on the hearth where it is burnt. A battery here in London may heat a wire in Edinburgh; the heat imparted to such a wire is transported by the electric current. The current is the carrier, not the creator of heat. The quantity of heat developed by the combustion of a definite weight of zinc in the battery is unalterable; but by the intermediation of the current it may be caused to appear either in the battery or elsewhere.

Thus the zinc may be oxidised, while the heat of oxidation appears at a distance from its birthplace. A similar phenomenon occurs in the muscles of the animal body. I rub my hands together. I strike my arms against my sides and back on a cold day. A savage will twirl a stick fixed in an appropriate piece of wood until he sets the wood on fire. Whence comes the heat which finally ignites the wood? Whence comes the warmth developed on the surfaces of the hands when they are rubbed together? It comes from the interior of the muscles of the arm. I can only rub my hands by the contraction of my muscles. Let us suppose the same contraction to occur without rubbing. A certain portion of the muscular tissue is oxidised; in popular language, it is burnt, and all the heat of the combustion is liberated in the arm. The case resembles that of the battery, when no heat is produced outside. But in the case of the rubbed hands, or of the rubbed wood of the savage, the oxidised muscle does not liberate within its own mass the entire heat due to its oxidation. Still, the total quantity of heat liberated by the oxidation of a certain weight of muscle is as invariable as the heat liberated by the oxidation of a certain weight of zinc; but muscular heat, like the heat of the battery, may be so distributed that a portion of it may be generated outside. In both instances it is a case of transport, and not of creation, of heat.

We have now to push this principle to the case of chemical decomposition. By the voltameter I can decompose water. When the current passes, the mixed gases are passed into a solution of soap, and bubbles are formed. I take some on my hand and apply a light, the gases reunite with detonation and evolution of heat. The quantity of heat thus produced is lost to the battery during the act of decomposition.

But you will readily understand me and agree with me when I say that the amount of heat which a battery can produce outside itself depends upon the store of heat at its disposal. It can never produce outside a greater quantity of heat than that due to the oxidation of the zinc. I heat a given length of platinum wire with ten cells and then with fifty cells; the increase of glow in the latter case is very manifest. The store of heat in the ten-cell battery is insufficient to produce the larger effect. If it did, heat would be created.

When the two ends of a voltaic battery are connected by a thick wire of good conducting material, the wire is not sensibly heated; but if the wire offers a resistance to the current, it is heated, and may if properly chosen be raised to a white heat.

Considering the battery as the hearth where the zinc is burnt, we might infer that the heat due to the combustion is liberated on the hearth itself, and that its amount depends solely upon the quantity of zinc consumed. This, however, is not the case. Let the battery, with its two ends united by a thick wire, be surrounded by a vessel of water, to which the heat developed by the oxidation, say of an ounce of zinc, is communicated, the quantity of heat developed is measured by the temperature of the water.

Let the battery, with its two ends united by a resisting wire, be placed in the same vessel, and let the heat generated in the battery by the oxidation of an ounce of zinc be again determined; this heat will be less than that observed in the last experiment. If the connecting wire be now enclosed in a separate vessel, and if the heat generated in the wire be thus determined, on adding this amount of heat to that liberated in the battery, a total heat is obtained exactly equal to that generated in the battery alone, when the good conducting wire was employed.

In fact, the absolute amount of heat generated by the oxidation of a given quantity of zinc is perfectly constant; but it may be distributed in various proportions between the battery and the external current.

Favre corroborates these results in a series of careful experiments, in which he interposed increased resistance by increasing the length of the wire connecting the two ends of the battery. His main results are given in the following table:—

Length of Wire.	*Internal Heat of Battery.* (UNITS)	*Heat outside the Battery.* (UNITS)	*Total.* (UNITS)
25	13127	4965	18092
50	11690	6557	18247
100	10439	7746	18185
200	8992	9030	18022

The heat developed in the wire uniting the two ends of the battery depends on the strength of the current, but it is not simply proportional to that strength. Let the strengths of a series of currents, determined either by the tangent compass or the voltameter, be represented by the numbers 1, 2, 3, 4; then the quantities of heat developed in the same wire by these respective currents are expressed by the numbers 1, 4, 9, and 16. The heat generated is therefore proportional to the square of the strength of the current. Preserving the strength of the current constant, the heat generated is proportional to the electrical resistance of the wire through which it passes. These important principles were established by Joule.

Thus, if one of two equal currents pass through a silver wire, and the other through a platinum wire of the same length and thickness, the heat generated in the platinum will be ten times that generated in the silver, because the resistance of the former is ten times that of the latter. To urge the current through the platinum in this case would, however, require greater battery power than that necessary for the silver.

Hence, when the same current is sent through a wire composed of alternate lengths of silver and platinum of equal thickness, the platinum spaces may be raised to a white heat, while the silver is not raised to the faintest glow.

When the self-same current is sent through a series of cells containing various compound liquids, the same amount of liquid is not decomposed in all cases. Let the current be sent in succession through a series of cells containing water, oxide of lead, chloride of lead, iodide of lead, and chloride of silver; then taking them in the above order, the weights of the liquids decomposed are represented by the numbers 9, 111.5, 139, 230.5, 143.5. Supposing the numbers to represent grains, we should have the following division between the electrodes:—

Water	8	oxygen	1	hydrogen
Oxide of lead	8	oxygen	103.5	lead
Chloride of lead	35.5	chlorine	103.5	lead
Iodide of lead	127	iodine	103.5	lead
Chloride of silver	35.5	chlorine	108	silver

Now, these numbers express the "combining proportions" of the respective substances. By the electric current the law of combination as regards quantity is in all cases exactly inverted. The substances combine in equivalent proportions; they are decomposed in precisely the same proportions. This is the celebrated law of electrolysis discovered by Faraday.

Now, let us consider what occurs in a single cell of a battery. Whenever the current heats a wire, produces decomposition, or performs work, each of these acts is accomplished at the expense of the heat in the battery. If the current turn an electro-magnetic engine which pumps water, or lifts a hammer, the battery loses heat by these mechanical acts. The precise amount of heat thus lost is restored by the falling of the water, or of the hammer. So also when water is decomposed in a voltameter, the battery loses an an amount of heat equal to that which would be produced by the recombination of the separated oxygen and hydrogen.

This explains why it is that a single cell of any battery is unable to decompose acidulated water in a voltameter with platinum electrodes. The heat developed in such a cell by the solution of one equivalent, or 33 grammes of zinc, amounts to 18,682 units; that is to say, it would raise the temperature of 18,682 grammes of water one degree. But the heat developed by the combustion of one equivalent of hydrogen is equal to 34,460 units, or nearly twice the quantity which the cell has to dispose of. To perform an amount of work represented by the number 34,460, by an amount of power represented by the number 18,682, would be tantamount to a creation of power, and is therefore at variance with the firmest principles of physical science.

If, instead of employing platinum electrodes, one of them be of zinc, and the other of platinum, then the current will pass, and the water will be decomposed, when the current from the battery coincides in direction with that produced by the couple in the voltameter, because the couple in the voltameter add their effort to the couple in the battery. But when the battery current and the voltameter current are opposed to each other, there is no decomposition.

The zinc electrode in this experiment may be superseded by a platinum electrode, covered with a film of hydrogen. For example, let the current from two cells pass for a short time through a voltameter furnished with platinum electrodes. The voltameter itself then tends to generate a current passing from the hydrogen electrode, through the liquid, to the oxygen electrode. When the current from a single cell coincides with the polarisation current in the voltameter, decomposition occurs, and it lasts till the film of hydrogen is consumed. But no decomposition occurs when the battery current is opposed in direction to that in the voltameter. The decompositions alleged to have been produced by a single cell may be explained by reference to these principles.

If, instead of acidulated water, sulphate of copper, with one electrode of copper and one of zinc, be employed, when the battery current passes from copper to zinc through the electrolyte, no heat is withdrawn from the battery. In this case, though the copper electrode is dissolved, the metal is again precipitated on the negative electrode, and this solution and precipitation neutralise each other thermally.

Notes.

THE Report (published last month) of the Select Committee appointed to inquire into the organisation and financial system of the Telegraph Department of the Post Office furnishes an instructive survey of our present telegraph system, with suggestions towards its improvement. The subject is treated under four heads—viz., I. Organisation of the Department. II. Facilities offered to the Public. III. Financial Administration. IV. Training of Military Telegraphists. We hope soon to notice the contents at greater length.

A Belgian correspondent of *Nature* calls attention to some new facts which seem to throw light on the action of that enigmatical apparatus, the radiometer. He has found, experimentally, that the glass globe becomes negatively electrified upon the whole of its exterior, when the instrument is submitted to solar or even obscure heat radiations of sufficient intensity, and this electricity is more intense on the hemisphere facing the radiant source than that opposed. There must, therefore (he says), be positive electricity on the inner surface. Next, the black face of the vanes is found to be electrified positively, and the bright face negatively. These electrical manifestations are of considerable intensity; and an explanation based upon them is offered.

A highly interesting speculative paper "On the Physical Nature of Comets," by M. Zöllner, has recently appeared in the *Astronomische Nachrichten* (Nos. 2082-86). He supports the theory that the comet's tail is formed by electric repulsion, from the sun, of the vaporous particles of water and hydro-carbon constituting it (vaporised by the sun's heat). The following conclusion is arrived at:—"If we suppose, for the secondary tail of Donati's comet, masses of the order of a water-molecule, then we have merely to attribute to the sun's surface and the elements of the comet's tail the same electric density as Dellmann has assigned to the earth's surface, to obtain velocities of the tail-elements of Halley's and Donati's comets, which are in agreement with the observations of Bessel and Pape."

We understand that a successful solution of the problem of duplex telegraphy on long submarine cables has been effected by Messrs. Muirhead and Taylor, who have for some time past been experimenting with this view on the cables of the Eastern Telegraph Company. The system has been working on the cables between Marseilles and Malta, and between Suez and Aden, for some months, and with good results in increase of the carrying capacity of the cables, and consequent diminution of delay in the transmission of messages.

According to recent advices from South Australia, the telegraph line from Adelaide to Perth, Western Australia, was being rapidly proceeded with. It had already been completed on the South Australian side as far as Streaky Bay, 400 miles beyond Port Augusta, and the 530 miles from that point to Fowler's Bay would be ready by September, six months before the expiration of the contract time. From Fowler's Bay to Eucla, which latter place is already connected by telegraph with Perth, there remain 230 miles to be made, and this was at once to be taken in hand. Referring to the great inconveniences felt through the cessation of telegraphic communication with England and to the proposal for the laying down of an alternative line, South Australia favours the idea of a cable from Western Australia to Galle; and although it is acknowledged that that would be more expensive than either of the other lines spoken of, thinks this would be amply compensated for by the fact that the termini would be in British territory, and not pass through that of another power, as does the cable from Port Darwin. The various Australian Governments are at present in communication with one another on the subject.

During a thunderstorm on the 11th of last month (we are informed by the *Journal of the Telegraph*), Miss Clapp, an operator of the Boston and Providence Railroad in Hyde Park, Mass., was struck by lightning and instantly killed. It appears that this lady, with two others, and the station agent, were in the office together. Miss Clapp had cut the instruments out of circuit, and was sitting in the window in close proximity to the cut-out, when the discharge occurred, her head being probably not more than ten inches from the switch. This would seem to indicate, and it is also the general impression of those in the office at the time, that the lightning came in by the wires, and passed over this small space, including her body in its route. About six inches from the cut-out, and directly over Miss Clapp's head, was a brass bracket, with ten brass checks suspended from it. These were in a line with the lady's neck, the left side of which was found to be slightly discoloured after death. The ticket-office window, as well as that in which the lady was sitting, were open, and a strong current of air was flowing through the former to the latter. No visible marks were left by the lightning, except the discoloration just referred to, a slight burning of the cut-out springs, and the detachment of a small piece of the window-frame where Miss Clapp sat. There was no gas, nor water-pipe, nor ground wire in the office. This is thought to be the first instance on record of the death of a telegraph-operator by lightning while in the office.

American papers contain obituary notices of General Marshall Lefferts, President of the Gold and Stock Telegraph Company, who died on the 3rd of July. He entered the telegraphic business in 1849, and originated the Bain lines between New York and Boston, and New York and Buffalo, becoming President of the Companies. He was afterwards engineer, and practically executive manager of the American Telegraph Company, which under him became one of the most popular and successful telegraphic organisations in the country. In his later connections with the Western Union and the Globe and Stock Telegraph Companies he largely extended the business of these. He was the first to introduce into practical use, on American lines, instruments for detecting electrical faults, and the first to reduce the resistance of relays to a common standard. It was in his military career, however, that he was brought most prominently before the public.

The *Pall Mall Gazette* notices a device by which economical Parisians diminish the receipts of the Telegraph Department. Most of the messages from one part of Paris to another are at present transmitted by pneumatic tube, and are delivered to the person to whom they are addressed upon the form or blank piece of paper (the use of printed forms not being compulsory in France, either for home or foreign telegrams) used by the sender. It is the rule of the telegraph offices that when words are written in a message and afterwards struck out, the sender shall, after excising them, add at the foot of the message, "So many words annulled," and append his signature, The sender of a message through the pneumatic tube has, therefore, but to write out some sixty or seventy words, entering into the fullest details, and afterwards to strike out all but the twenty to which he is limited. His friends, who are, of course, in the secret, read the message through, and the majority of the words, though they have been "*rayés nuls*" by a confiding clerk, are, perhaps the most important of the whole.

The number of messages passing over the lines of the Cuba Submarine Telegraph Company, Limited, during the month of July, 1876, was 3003, estimated to produce £2700, against 2440 messages, producing £2342, in the corresponding month of last year. The traffic receipts for the month of May, estimated at £2700, realised £2731.

The traffic receipts of the Direct United States Cable Company, Limited, at 3s. per word, for the week ending 22nd July, amounted to £2500; 29th, £2500; 5th August, £2520.

The traffic receipts of the Great Northern Telegraph Company for the month of July, were, this year, 470,508 francs; last year, 412,823 francs. The total traffic receipts, 1st January to 31st July, were, this year, 2,709,895 francs; last year, 2,346,090 francs.

The traffic receipts of the Direct Spanish Telegraph Company (Limited), for the month of July, 1876, were £538 16s. 6d., against £1834 7s. 4d. in the corresponding period of last year.

Electrical Science in Foreign Journals.

COMPTES RENDUS OF PARIS ACADEMY.

No. 3: 17th July, 1876.

Fourth Note on Electrical Transmissions through the Ground. By M. du Moncel.—Reserved.

On Measurement of the Electric Resistance of Liquids by means of the Capillary Electrometer. By M. Lippmann.—See page 210.

On some Phenomena produced by Faradisation of the Grey Cortex of the Brain. By M. Boche-Fontaine.

Faradisation of the points called *motor centres of the limbs*, acts also on the various apparatuses of organic life (vessels, iris, bladder, glands, &c.). But it is not proved that the grey cortical substance is excitable by faradic currents. To obtain the effects, on limbs or other parts, pretty intense excitations are necessary, and the subjacent white substance is thus probably reached and excited; this contains excitable fibres that are connected with the centres of direct excitation of the muscles and glands.

No. 4: 24th July.

On the Production of Electric Effluves. By M. Boillot.

Two arrangements described. In the first, two narrow tubes filled with powdered and calcined graphite, and fixed near each other in a long vessel; each tube has a platinum wire connected with the graphite. Two other tubes enter the vessel; one of them penetrating two or three centimetres: one brings, the other receives, the gases. In the second arrangement, one long vessel is fixed within another, protruding 2 centimetres above it. The space between them is filled with graphite powder, and the annular contour closed with gum-lac. A platinum wire passes through the outer envelope (at the top) to the carbon. In the smaller vessel are fixed three small tubes; one contains powdered graphite with platinum wire attached; the two other tubes are for the gases, as before. In both arrangements, the effluve is generated between the graphite tubes.

Photographic Inscription of the Indications of Lippmann's Electrometer. By M. Marez.

The electrometer has the advantage of giving the *form* of electric variation in each muscular act (a galvanometer only shows the existence of such variation). The opacity of the mercury column is utilised to obstruct, to variable extent, a slit through which a beam of light is admitted to a photographic screen. The form of the electrometer is somewhat modified; thus, the tube is one of thick glass, having on one side a plane-polished face, through which the capillary column mercury appears as a thin, very luminous line. The author shows photographic curves obtained from the hearts of a tortoise and a frog.

ANNALES DE CHIMIE ET DE PHYSIQUE.

July, 1876.

Memoir on Magnetism. By M. Gaugain.

The first chapter is on the processes of observation. From the curve of demagnetisation (got as described in a previous memoir) may be deduced that of magnetic intensities, and this mostly coincides with that got by the method of oscillations. The current of demagnetisation is, within certain limits, nearly independent of the diameter of the ring submitted to induction. In chapter 2 he studies the changes in the magnetic state of a magnet when put in contact with a piece of soft iron. The increase through application of an armature is instantaneous. The magnetisation of one section results in part from the reaction of all the other sections. He considers various modes of application of armature—the partial demagnetisation through friction of an armature and a series of shocks, and the stability of residual magnetism—and interprets the results theoretically. Chapter 3 deals with the Elias process of magnetisation. The magnetism developed in a bar by a current of given intensity varies with different circumstances, and especially with the number of passes. We may superpose five or six layers of magnetism, alternately positive and negative, and this without varying the intensity of the current. The method of demagnetising by a series of alternating currents is described. Increase of the intensity of an inducing current does not merely result in making the magnetism penetrate to a greater depth. Chapter 4 refers to the method of simple touch. The influences of length, annealing, temperature, inclination, &c., are studied. It is shown, *inter alia*, that it is useless to rub the whole length of the bar with the magnet; and that the magnetisation is greater where the friction finishes than where it commences. Chapter 5 treats of the method of double touch. The ordinate of the curve, representing at a given point of a bar the total magnetism developed by the simultaneous contact of two magnets, is approximately equal to the sum of the ordinates representing the magnetism developed by each of them. The curve of permanent magnetism is different from that of total. The two magnets brought to double contact near one end concur very unequally in development of magnetism. The distribution of magnetism is considered in a variety of cases, and the best way indicated for making the passes.

Dingler's Polytechnisches Journal.

First July Number, 1876.

Automatic Transmissions by the Hughes Telegraph. By M. Hottenroth.

This cannot well be described without figure. The sending of the current is by means of a brass roller and a contact spring; on the roller are arranged spirally a series of conical holes, corresponding to the keys of the Hughes apparatus. The maximum performance of the Hughes, with 120 turns a minute and 1·75 signals each turn, amounts (necessary deductions being reckoned) to about 1500 words in the hour. In automatic transmission, with 160 turns, this rises to 2000 words. All the turns are here fully utilised. For ordinary telegraphic purposes, a Hughes automaton seems as little advantageous as a Morse automaton; it is rather to be recommended in dealing with accumulations of telegrams.

On Aniline Black, obtained by the Electrolytic Method. By M. Coquillion.

A product corresponding to the industrial aniline black seems to be furnished only by the hydrochlorate and sulphate of aniline. These being used in concentrated solution, a current of the strength of two Bunsen elements separates the black at the positive pole in twenty-four hours, in form of a thick pulpy mass, while hydrogen is developed at the negative pole. The precipitate, washed and dried, dissolves in concentrated sulphuric acid with dark violet colour, and on addition of water there is a green precipitate. Cotton dyed in aniline black gives exactly the same reaction. The green flocks pass into black again, on neutralising the acid with ammonia or potash. M. Coquillion uses as electrodes carbon pieces 100 metres long, and winds round the upper part platinum wire, which is connected with the battery; the lower part dips in the solution. The carbon pieces, however, are previously exposed in a red hot porcelain tube three hours to chlorine gas, then boiled in nitric acid, again treated with chlorine, and washed with distilled water. This is to free the carbon from metal; and it appears that aniline black may be formed without the intervention of a metallic compound.

Annales Télégraphiques.

March-April, 1876.

The Electro-Diapason (continued). By M. Mercadier.

It appears from this study that the isochronism of the vibrations of a diapason is not absolutely rigorous; the duration of its period depends on the amplitude and the temperature. As regards the use of a diapason as chronograph or interrupter, an instrument will give identical results at different times, only if we operate at the same temperature and give the vibrations the same amplitude. If complete identity and large amplitudes be not needed, as is more usually the case, then, provided we do not exceed an amplitude of three to four millimetres, and operate at temperatures little different, we are certain to have the same number of periods per second to near 0·0001.

Electric Quantities and their Measurement in Absolute Units (continued). By M. Blavier.

This paper, hardly suited for abstraction, treats of propagation of electricity.

Comparative Examination of the Batteries used in Telegraphy. Report by M. Gaugain (continued). —Reserved for translation.

Modifications introduced into the Marié-Davy Battery by the Employment of Retort Carbon.—Employment of the same Carbon in other Batteries. By M. Lagarde.

The Marié-Davy battery is enabled to act till complete reduction of the sulphate of mercury. The effects of the carbon are of three kinds—(1) A physical action, in draining the matter, and making it accessible to the water, while also augmenting considerably the surface of the depolarising plate; (2) an electric action, as it is a conductor, and diminishes the resistance; (3) perhaps also a chemical action of presence, favouring the decomposition of the sulphate.

Description of a New Electro-Magnet System with Iron Bobbins. By M. Fridblatt.

The object is to diminish the mass of iron by increasing the surface of action, and thus get an apparatus sensitive enough to act with currents of small intensity, so as to diminish the effects of induction and derivation on lines.

Automatic Commutator for Call of Secondary Offices. By M. Roussel.

Review.

Exposé des Applications de L'Electricité. Par Le Comte Th. du Moncel, &c., &c. Troisième Edition, entièrement refondue. Tome Troisième, 1874; Tome Quatrième, 1876. Paris: Lacroix. Prix, 12f. 50c. chaque volume.

Count du Moncel has at length completed the entire revision and enlargement of his magnificent and laborious work, the "*Exposé des Applications de L'Electricité.*" In this new edition, as we learn from the preface to the first volume, the Count has been aided by M. Francisque-Michel, and we heartily congratulate both the author and his collaborateur at the successful and altogether admirable completion of so great a task. The work before us is certainly one of the most valuable contributions ever made to the literature of electrical science; it is a monument of indefatigable industry, and will render Count du Moncel's name ever famous in the annals of electricity. For in the four large volumes that constitute the work—each volume containing some 500 closely-printed pages—there is brought together a detailed description of the vast mass of electrical inventions that have been the characteristic product of this century. But Count du Moncel has given us far more than a mere catalogue of instruments. In a systematic and perspicuous manner the author traces the growth of each application of electricity; discusses and explains those portions of pure science that bear on each branch of his subject, and classifies in a most useful manner each group of electrical apparatus. When to this is added the fact that we have in these volumes the very latest electrical discoveries, and that throughout the whole a careful accuracy is discernible, it will be evident that this is really a *magnum opus*, invaluable to physicists generally, but indispensable to electricians, telegraphic engineers, and instrument-makers. One great convenience of this work is that, if consulted, it will save the time that now is often lost in searching for previous electrical discoveries; and also turn from useless labour the inventive genius that is frequently spent on reproducing already existing inventions.

In The Telegraphic Journal for 1st April, 1875, we gave a brief summary of the contents of the first and second volumes of this work; the third and fourth volumes are now before us, and, it may be useful to our readers if we give an outline of this latter and more important half, so far, that is, as our space will permit.

The third volume is entirely devoted to the electric telegraph in all its manifold phases. Opening with a short introduction on the history of the Electric Telegraph, the first chapter describes the different needle-telegraphs that have been invented. Chapter 2 gives an account of the various dial-telegraphs; here the number of modifications is much greater. And when we come to the writing-telegraphs detailed in chapter 3, we find no less than from seventy to eighty different instruments in this class alone. Concerning the priority of discovery in this direction, the author speaks in severe terms of the claims set up by Morse, and remarks—"There is nothing original in the invention of Mr. Morse. Any person who has found that an electro-magnet gives at a slight distance a sufficient mechanical effect, might have arranged an analogous combination perhaps under better conditions." A letter from the American physicist, Page, dated Washington, March 26th, 1860, is quoted, which gives an unbiassed view of Morse's discovery. Mr. Page remarks that had it not been for Wheatstone's electro-magnetic receiver, the Morse instrument would have been an invention of comparatively little value. Mr. Page shows that the first arrangement made by Morse had large and cumbrous electro-magnets wound with wire of the same size as the line-wire, and that the residual magnetism and other faults prevented any good results being obtained. Morse having been to Europe, returned with one of Wheatstone's little electro-magnets, and with this achieved his first success. As Count du Moncel remarks, the indemnity of 400,000f. paid by the European Governments to Morse for the use of his telegraph only illustrates once again the sad fact that the true inventors rarely receive the fruit of their inventions. Du Moncel asserts, what is now generally admitted, that Steinheil was really the inventor of the first writing-telegraph, although the Morse instrument was a more practical and expeditious arrangement. An important letter bearing on the early history of the Electric Telegraph, and Steinheil and Wheatstone's relation thereto, will be found in the *Magazine of Popular Science* for 1837, page 108.

From writing-telegraphs, where an excellent account of Wheatstone's rapid automatic-transmitter will be found, the author passes to printing, autographic, and submarine telegraphs, in chapters 4, 5, and 6. Chapter 7 contains a description of the different relays, introducing the subject by a valuable discussion on the subject from a physical point of view. Here will be found the laws for the construction of relays, and other practical information of considerable value. Edison's electro-chemical relay—the electro-motograph—is here described, and in this and several instances the author acknowledges his indebtedness to our columns. Chapter 8 is occupied with "Telegraphs for the Multiple Transmission of Messages"; and the last chapter with "Electric Bells, and the various Systems of Call in Use"; the volume concluding with an account of the different means of cipher-signalling, and the cryptographs employed.

The chapter on multiple transmissions we especially commend to our readers for its excellent arrangement and comprehensive scope. The system of multiple transmission, by making use of the small intervals of time between each signal, has not come into use in this country; but an apparatus by Meyer, here fully described, seems destined to make its way. We had intended giving an outline of the working of this important instrument, but want of space forbids us to do more than refer our readers to the volume itself. From the report of the Commission that examined Meyer's apparatus, we learn that it is capable of transmitting twenty-eight messages per hour from each sender; and as four messages can be simultaneously transmitted along one wire, this yields a maximum of 112 messages per hour. An average speed of twenty-two to twenty-three messages per sender, or ninety-two per wire, can be kept up by this instrument; whereas a Morse gives only eighteen, and the Hughes twenty-two per hour; the latter, with two senders at each apparatus, only giving forty-five messages, or less than half the speed of the Meyer instrument per wire.

(To be continued.)

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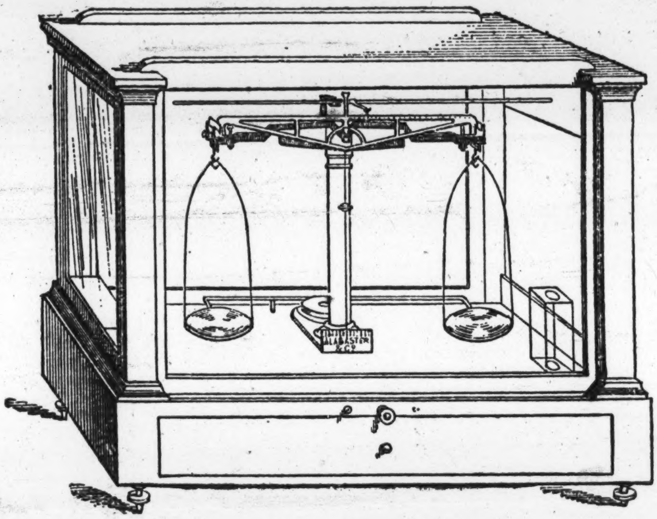

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LONDON: PRINTED FOR THE PROPRIETOR, BY JOHN PENDLEBURY, AT THE CHILDREN'S HOME, BONNER ROAD, E.—AUG. 15, 1876.